The gas chromatograph was set to a split vent flow of 20 ml/min resulting in a total of 100 ml/min flow. The purge vent was set to 5 ml/min resulting in a 1:20 split ratio. The gas chromatograph was operated at 120 degree centigrade initially for 7 minutes then ramped to 250 degrees centigrade at 10 degrees centigrade per minute, then programmed to remain at that temperature for 10 minutes. A Hewlett-Packard FFAP 50 meter x 0.2 uM column was installed for these analyses.

The mass spectrometer was programmed to scan from 35 to 450 M/Z.

For the series of vinyl coated samples, the headspace sampler operated at 140 degrees centigrade. Each sample consisted of approximately 24 square inches of material rolled into the headspace sampler vial.

Increasing temperature of the headspace sampler resulted in successively higher amounts of degradation materials to be transferred to the gas chromatograph. Seven peaks were predominant in this series of samples, indicating at least seven separate compounds. There were also several other small peaks with signals too low to provide sufficient qualitative information for characterization.

Three samples of differing materials were analyzed at 140 degrees centigrade. These included the bronze vinyl coated fiberglass from Arizona, the gray vinyl coated material included with the bronze material, and another sample of gray vinyl coated material from a round mailing tube. Each of these samples exhibited similar chromatographic behavior. That is, they all exhibited the same seven peaks as shown on the associated chromatographs attached to this report.

The mass spectra of each of these peaks was matched with NBS standard spectra and the ten best matches were listed for each peak. A list of the seven most likely compounds from this analysis also is attached. It can been inferred from this data that these compounds represent oxidation products of the vinyl material and associated plasticizers.

It can be envisioned that different product ratios can be formed depending on environmental conditions. The major product appears to be a small molecular weight ketone, amine or acid formed from oxidative cleavage of HCl from the polyvinylchloride. This can result in the formation of chlorinated polyenes, low molecular weight compounds such as propanes, cyclopropanes and butanes, cyclobutanes, and their associated acids. These compounds typically exhibit high vapor pressures, thus the odors associated with aging of the vinyl coating.

The seven compounds identified by us as being released from the weathered screen materials are ketones, amines, and low molecular weight organic acids. I have surveyed the toxicology literature for information on the potential adverse health effects that might result from exposure to these materials. As I suspected there was very little information in the literature as to the human toxicity of these compounds. However, it is well recognized that compounds such as these (i.e. ketones, amines, and weak organic acids) can be strong irritants to the nose, eyes, upper respiratory tract, and mucous membranes. Signs and symptoms related to exposure to these compounds might in some cases mimic those of a cold or flu. These would consist of eye irritation or red eyes, a runny nose, a raspy feeling in the throat, some hoarseness, and possibly bronchitis. Since these are all irritant effects it is to be expected that once the offending agent was removed, then these symptoms should reverse themselves and the health status should revert back to normal. It is important to stress that chronic or long-term effects resulting form exposure to these agents is not to be expected.

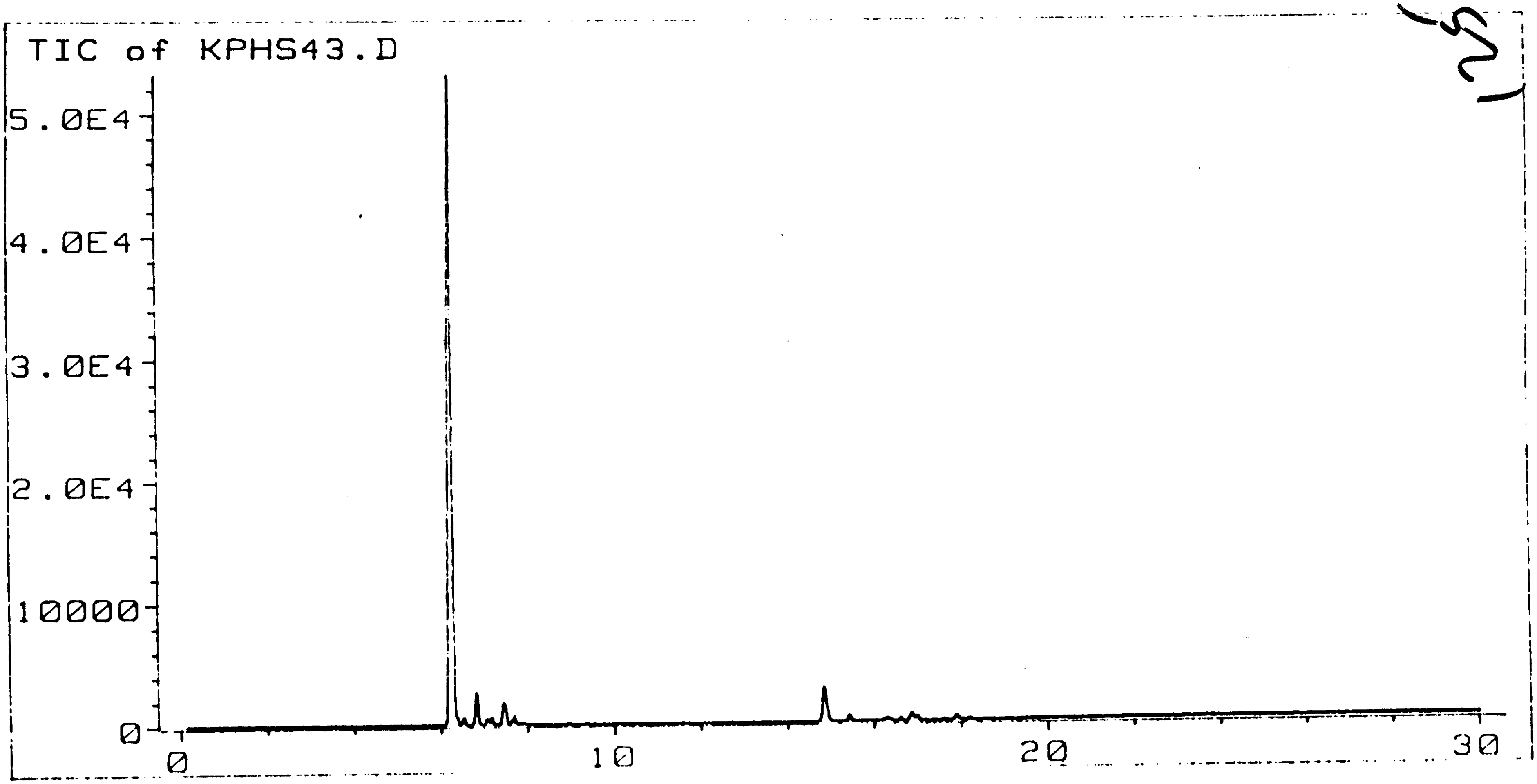
I hope this provides you with the information needed. If you have any questions concerning our analyses and/results or need any additional information, please do not hesitate to contact me. As always, I remain

Sincerely yours,

Robert G. Meeks, Ph.D., D.A.B.T.

CHEMICALS IDENTIFIED AS BEING PRESENT IN
THE WEATHERED SCREENING MATERIAL SUPPLIED BY
PHIFER WIRE, INC.

Peak 1	2-Pentanamine, 4-methyl-	CAS #108-09-8
Peak 2	Butanoic Acid, 3-oxo-,2-methylpropyl	CAS #7779-75-1
Peak 3	2-Pentanone, 5-chloro	CAS #5891-21-4
Peak 4	Propane, 1,1'sulfonylbis	CAS #598-03-8
Peak 5	Ethanone, 1-cyclobutyl-	CAS #3019-25-8
Peak 6	2-Butanone, 4-butoxy-3-methyl-	CAS #54340-94-2
Peak 7	Acetamide, N-[2-[3,4-dihydroxy-.alpha.	CAS #28177-12-0



BRONZE VINYL COATED FIBERGLASS

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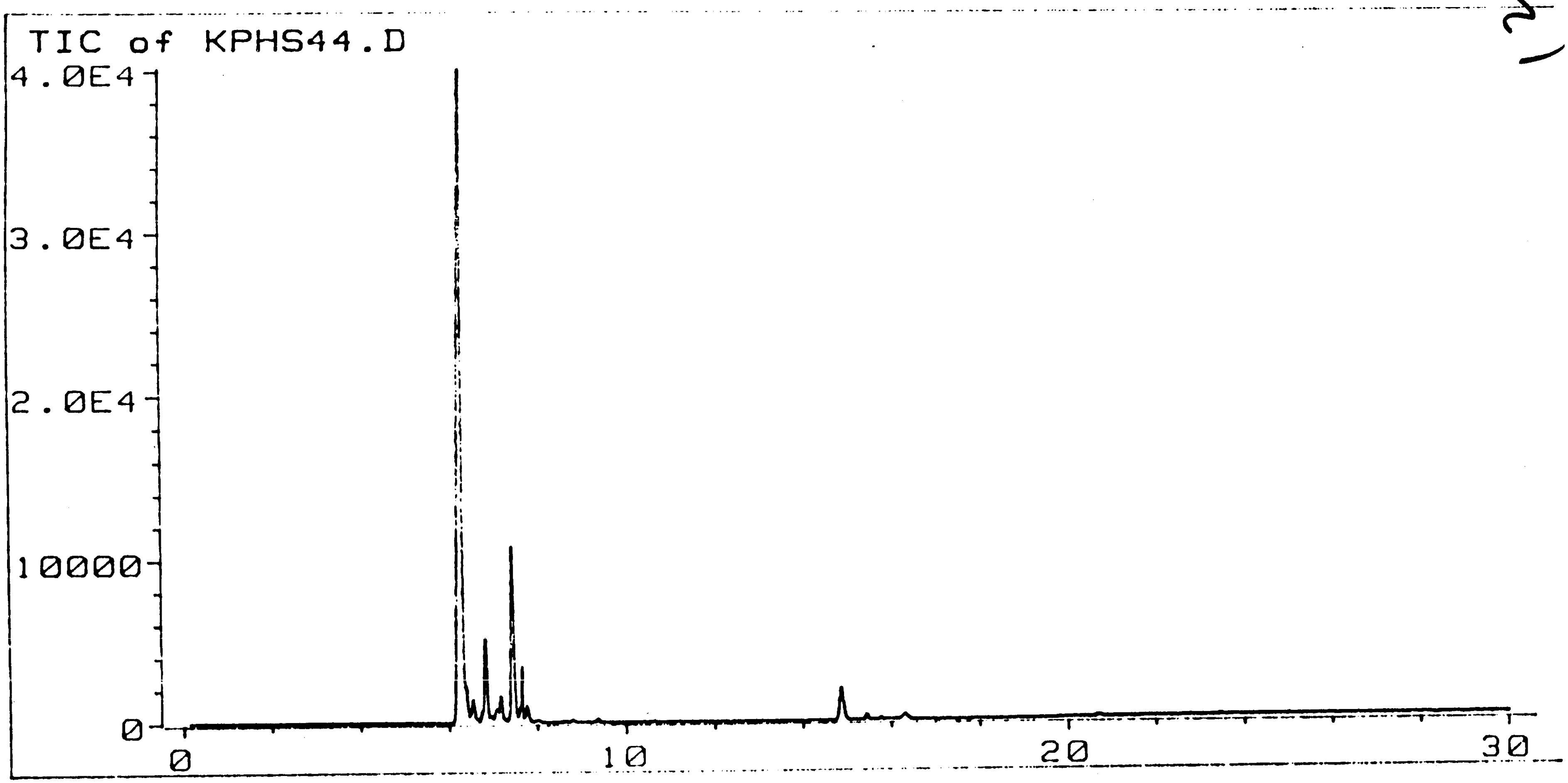
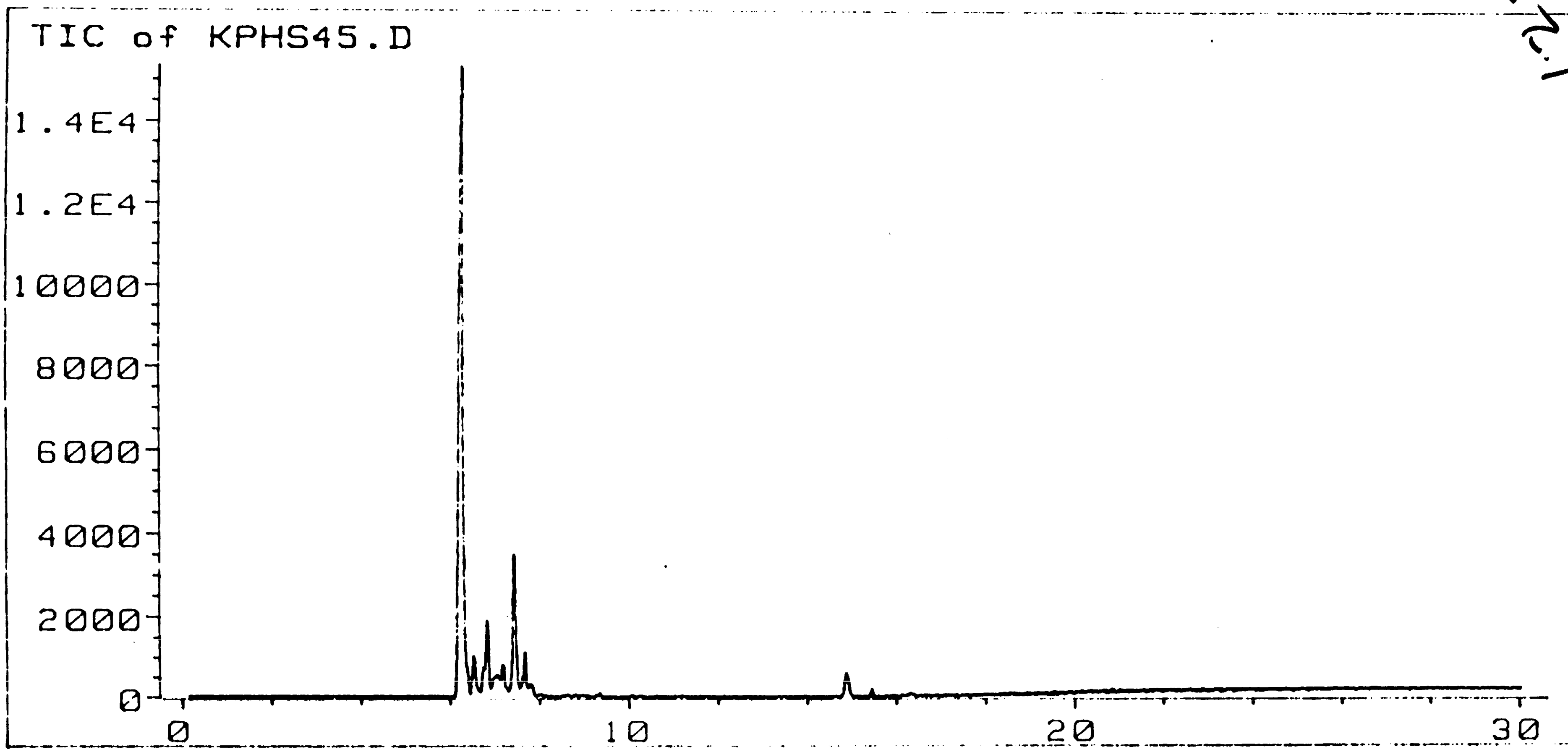
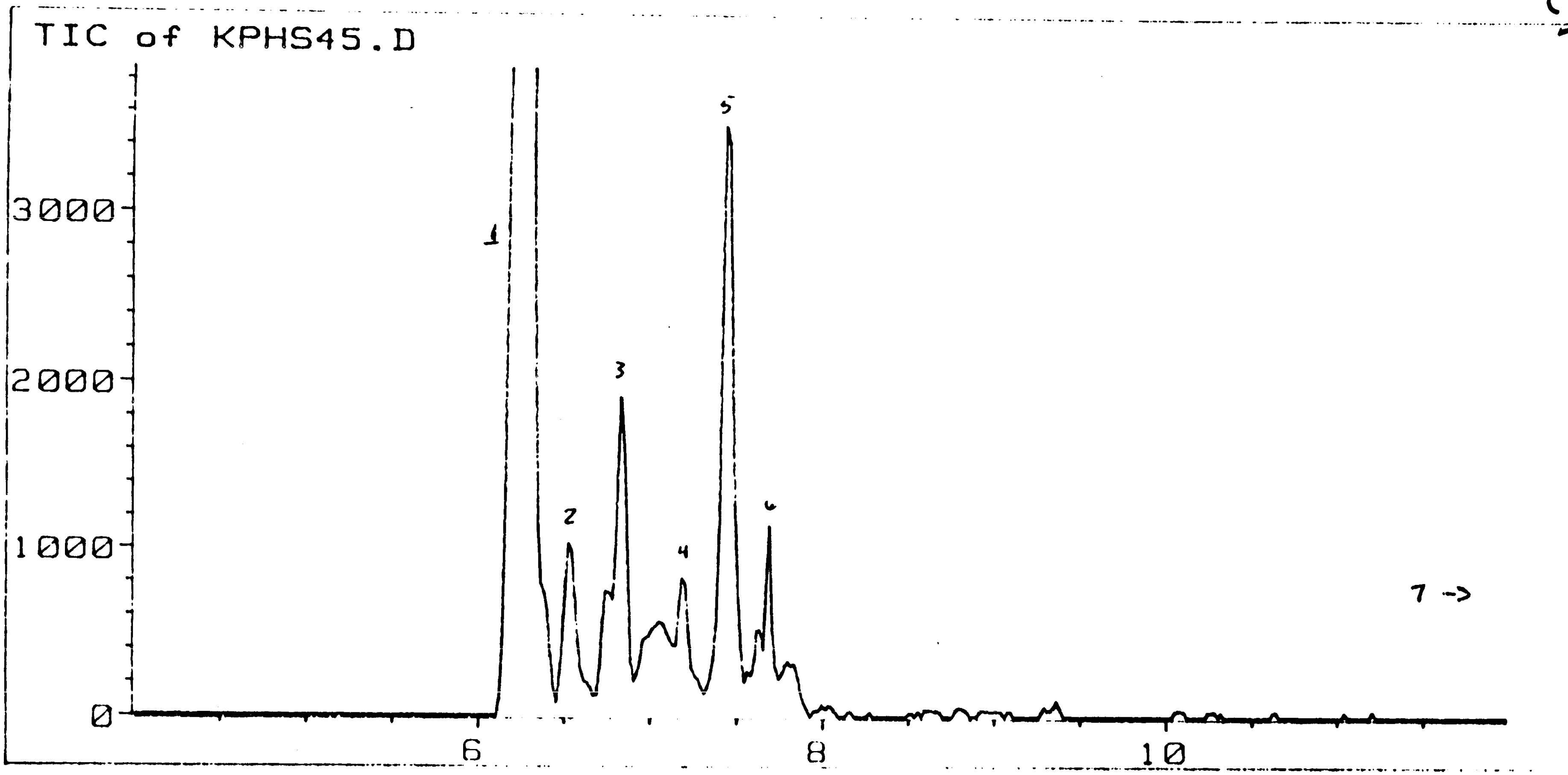
92)



GRAY VINYL COATED FIBERGLASS



GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE



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Peak 1

LIBRARY SEARCH RESULTS

Scan 344 (6.322 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: 2-Pentanamine, 4-methyl- (9CI)	108098	1391	9794
2: 2-Hexanamine, 4-methyl- (9CI)	105419	2523	9785
3: 2-Butanamine, 3-methyl- (9CI)	598743	686	9771
4: Dodecanoic acid, 11-amino-, methyl ester	56817926	19553	9771
5: 2-Heptanamine (9CI)	123820	2525	9764
6: 2-Butanamine, 3,3-dimethyl- (9CI)	3850304	1398	9761
7: 2-Hexanamine (9CI)	5329793	1401	9754
8: Cyclopropane, 1-bromo-1,2-dichloro- (8CI	24071634	13622	9733
9: Cyclopropane, 1,1-dibromo-2-chloro-2-flu	24071576	22007	9733
10: Phenol, 4-[2-(methylamino)ethyl]- (9CI)	370989	7330	9726

RETRIEVE
Which match (1 to 10):

Y: Set of 4 MS
X: Scan 344 (6.322 min) of KP

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Scan 342 (6.282 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
38.10	28	42.10	72	45.95	43	56.05	46
40.00	1531	44.00	10000	55.05	21	57.05	44
41.10	201	45.00	146				

LIBRARY SEARCH RESULTS

Scan 355 (6.526 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE Peak #2

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Butanoic acid, 3-oxo-, 2-methylpropyl es	7779751	8653	9237
2: Nickel, [5,6,17,18-tetrahydrotetrabenzo[	72101349	37007	8912
3: Propane, 2-(ethenyloxy)- (9CI)	926658	637	8745
4: Propanamide, 2-methyl- (9CI)	563837	676	8634
5: 1H-Cyclonona[1,2-c:5,6-c']difuran-1,3,6,	21794014	36955	8607
6: Butanoic acid, 2,2-diacetyl-3-oxo-, ethy	19446516	17412	8519
7: Acetamide, N-[2-(acetyloxy)-2-[4-(acetyl	55145647	28994	8505
8: 1-Butanamine, 3-methyl-N-(3-methylbutyl)	28023747	13259	8481
9: Pentylamine, N-isobutyl-N-nitroso- (8CI)	28023805	13260	8477
10: 4,15:5,10-Dimethanobenzofuro[3',2':7,8][	24945935	34414	8462

RETRIEVE
Which match (1 to 10):

Y: #8653 Butanoic acid, 3-oxo
X: Scan 355 (6.526 min) of KP

LIBRARY SEARCH RESULTS

Scan 372 (6.832 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE
Peak #3

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: 2-Pentanone, 5-chloro- (8CI9CI)	5891214	2947	9869
2: s-Indacen-1(2H)-one, 3,5,6,7-tetrahydro-	54889597	15484	9780
3: 3-Pentenoic acid, 4-methyl- (8CI9CI)	504858	2318	9765
4: 2-Hexanone, 5-methyl- (8CI9CI)	110123	2398	9765
5: 3(2H)-Furanone, 4-hydroxy-5-(hydroxymeth	66727944	6171	9708
6: 1-Propen-2-ol, acetate (8CI9CI)	108225	1242	9699
7: 3-Penten-2-one, 4-methyl-, O-methyloxime	56336119	3707	9681
8: 2-Propanone, 1-(1-methylethoxy)- (9CI)	42781124	2629	9673
9: 2-Pentanone, 5-(acetyloxy)- (9CI)	5185977	6188	9648
10: Acetic acid, 2-propenyl ester (9CI)	591877	1249	9632

RETRIEVE
Which match (1 to 10):

Y: #2947 2-Pentanone, 5-chlor
X: Scan 372 (6.832 min) of KP

LIBRARY SEARCH RESULTS

Scan 391 (7.204 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE r.a.k#4

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Propane, 1,1'-sulfonylbis- (9CI)	598038	7162	9321
2: 4-Hepten-2-one, (E)- (9CI)	36678430	2150	9318
3: 2-Heptanone, 6-methyl-5-nitro- (9CI)	66972029	11269	9296
4: 2,4-Oxazolidinedione, 5,5-dimethyl- (8CI	695534	4000	9293
5: Propane, 2-methyl- (8CI9CI)	75285	98	9290
6: 4-Penten-2-one (8CI9CI)	13891877	522	9282
7: Butane, 2,2-dichloro-3-methyl- (8CI9CI)	17773669	5489	9241
8: 4H-Pyran-4-one, 3,5-diacetyltetrahydro-2	55030665	17148	9239
9: 2,3-Pentanedione, 4-methyl- (8CI9CI)	7493585	2346	9195
10: Acetic acid, 2-propenyl ester (9CI)	591877	1249	9188

RETRIEVE
Which match (1 to 10):

Y: #5489 Butane, 2,2-dichloro
X: Scan 391 (7.204 min) of KP

LIBRARY SEARCH RESULTS

Scan 404 (7.436 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE

r.a.k#5

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Ethanone, 1-cyclobutyl- (9CI)	3019258	1083	8964
2: 3-Octen-2-one, 7-methyl- (9CI)	33046810	5670	8842
3: 1-Butanol, 3-methyl-, acetate (9CI)	123922	4155	8543
4: Cyanic acid, 2,2-dimethylpropyl ester (9	1459445	2250	8541
5: 2-Pentanone, 3-methylene- (8CI9CI)	4359777	1088	8514
6: 2H-Pyran, 3,4-dihydro-6-methyl- (8CI9CI)	16015115	1098	8500
7: 3-Hepten-2-one (8CI9CI)	1119444	2110	8480
8: 3-Butyn-2-ol (8CI9CI)	2028639	214	8405
9: 1-Propanone, 2-methyl-1-[2-(1-methylethy	56259155	7837	8394
10: 5-Undecene, 8-methyl-, (E)- (9CI)	39546855	10358	8373

RETRIEVE
Which match (1 to 10):

Y: #5670 3-Octen-2-one, 7-met
X: Scan 404 (7.436 min) of KP

LIBRARY SEARCH RESULTS

Scan 418 (7.690 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE ...K6

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: 2-Butanone, 4-butoxy-3-methyl- (9CI)	54340942	8731	9260
2: 3-Buten-2-one, 3-methyl- (8CI9CI)	814788	509	9140
3: 3-Penten-2-one, 3,4-dimethyl- (8CI9CI)	684946	2106	9011
4: 2-Butanone, 4-hydroxy-3-(hydroxymethyl)-	6868979	4429	9008
5: Cyclopenta[c]furo[3',2':4,5]furo[2,3-h][	55446270	29503	8949
6: Ethanone, 1-cyclopropyl- (9CI)	765435	507	8890
7: Ethanone, 1-(7-oxabicyclo[4.1.0]hept-1-y	15121014	5563	8881
8: 2-Pentanethiol, 2-methyl- (8CI9CI)	1633972	2830	8839
9: Propane, 2-methyl- (8CI9CI)	75285	98	8779
10: Heptane, 4-azido- (8CI9CI)	27126223	5730	8779

RETRIEVE
Which match (1 to 10):

Y: Set of 4 MS
X: Scan 418 (7.690 min) of KP

LIBRARY SEARCH RESULTS

Scan 818 (14.882 min) of KPHS45.D
GRAY VINYL COATED FIBERGLASS FROM MAILING TUBE T...K7

Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Acetamide, N-[2-[3,4-dihydroxy-.alpha.-[	28177120	38099	9334
2: Acetic acid, silver(1+) salt (8CI9CI)	563633	10151	9092
3: Butanoic acid, 3-hydroxy- (9CI)	300856	1553	8942
4: 2-Butanone, 3-hydroxy- (8CI9CI)	513860	729	8832
5: Propanoic acid, 2-(aminooxy)- (9CI)	2786223	1631	8779
6: Compactinervine, diacetate (ester) (8CI)	2111855	35159	8725
7: 2-Propanone, 1-methoxy- (8CI9CI)	5878193	737	8702
8: Butanoic acid, 3-hydroxy-, ethyl ester,	35608641	4434	8660
9: 2-Pentanol, 3-chloro-4-methyl-, (R*,S*)-	74685486	4917	8614
10: Propane, 1-(1-methylethoxy)- (9CI)	627087	1490	8591

RETRIEVE
Which match (1 to 10):

Y: #1553 Butanoic acid, 3-hyd
X: Scan 818 (14.882 min) of K

ENVIROCOMP

INDOOR AIR QUALITY INVESTIGATION
GERYK'S RESIDENCE
HATFIELD, MASSACHUSETTS
OCTOBER 9, 1992

INTRODUCTION

An indoor air quality assessment was performed by Envirocomp personnel at the Geryk residence on October 9, 1992. The purpose of the assessment was to attempt to identify any specific chemicals and their concentrations associated with coated fibrous glass screens. This report details the assessment protocol, sampling results, computer literature search, and conclusions of the assessment.

BACKGROUND INFORMATION

The owner of the residence, Mr. Geryk, reported that objectional odors are released by the screens in selected windows and skylights. He stated that the strongest odors occur during the day when direct sunshine contacts the windows/screens. The screens have been taken out of the residence some time ago. They stated that the odors were much worse when the screens were newer and the temperature (both ambient and their specific location with direct sunlight). For this project, they were reinstalled the day before sampling was performed.

SAMPLING DETAILS

The Geryk residence is located at #12 Plantation Dr. in Hatfield, Ma. The house, a single-floor ranch with a basement and an attached two car garage, is located in a residential neighborhood. The outside weather conditions at the time of arrival, 12:15 pm, were clear and cool with the measured temperature at 68 degrees Fahrenheit and the relative humidity at 42.5%.

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125 North Elm Street, Westfield, MA 01085 Tel. (413) 568-4616 Fax (413) 568-4706

Upon entering the house with Mr. and Mrs. Geryk they informed me of a faint odor which they smelled and how they believed it was coming from the screens. The screens are located in two skylights, a slider door, and a kitchen window. The measured average temperature inside was 73 degrees Fahrenheit and the relative humidity was 44.4%.

ASSESSMENT PROTOCOL

The sampling was performed on a mostly sunny day during the time period in the early afternoon when direct sun makes contact with the windows/screens. Upon arrival, pre calibrated air sampling pumps connected to a sampling train of charcoal tubes and Tenax adsorption tubes were strategically located in the den area, kitchen, and in the immediate vicinity of the skylights.

Sampling was conducted at both skylights, the sliding door located at the north wall exiting the kitchen/den area, and over the sink area in the kitchen (a total of 4 sampling locations). All sampling equipment was calibrated on site prior to the collection of samples. After the sampling equipment was set out and turned on, both the Envirocomp Industrial Hygienist and the Geryk's exited the house. It was not reentered until the conclusion of the sampling, approximately 2 hours later. This sample time was based on the sampling of approximately 100 liters of air.

Upon completion of sampling, all sample tubes were sealed and sent to an independent laboratory for Gas Chromatography/Mass spectroscopy (GC/MS) analysis following standard chain of custody protocol. The Laboratory, Environmental Health Laboratory, Cigna Loss Control Services, is a PAT accredited Laboratory located in Hartford, CT.

AIR MONITORING RESULTS

All samples provided similar results in where the chemicals were collected, and the chemicals identified. The charcoal adsorption tube (the first tube) collected the identifiable peaks, while the Tenax tube had no identifiable peaks (this was expected; the Tenax tube was downstream from the charcoal, and was in place to either identify breakthrough or materials that do not adsorb onto charcoal).

The following section of this report is a description of the findings categorized by the chemicals identified.

UNIDENTIFIED HYDROCARBONS

On each of the samples there were unidentified hydrocarbons at low levels. The Mass Spectrometer has a library of approximately 49,000 chemicals. However, for a match to be made, the peak (related to the amount of the chemical collected) needs to be large enough for it to be identifiable. For these samples, which is typical, various small peaks of aliphatic hydrocarbons were not identifiable. They were summed by weight, divided by the amount of air sampled, and reported as "Unidentified Hydrocarbons" in milligrams per cubic meter of air (mg/M^3).

XYLENE

On each sample, a small concentration of xylenes (all isomers) were identified. Xylenes may normally be found in solvent based paints and thinners, gasoline, and other petroleum based hydrocarbons. The xylenes are quite volatile, with vapor pressures of approx. 7 millimeters of mercury (mm HG) @ 21° C, meaning that they readily evaporate off of a liquid that they are contained in. Although workplace exposure limits are not applicable to a residential setting, they are provided here only as a rough comparison of what is considered to be safe in the workplace to the levels found during this assessment in a residential setting. The OSHA limit for xylenes is 435 mg/M^3 averaged over an 8 hour day. The concentrations found in the Geryk residence ranged from 0.015 to 0.021 mg/M^3, which is many times below this workplace limit.

TOLUENE

Toluene, another aromatic chemical like xylene, was found on each of the samples at very low levels. Toluene may also be found in gasoline, paint thinners, and other petroleum distillates. Toluene is a volatile chemical with a vapor pressure of 37 mm HG @ 30° C. The current OSHA limit is 375 mg/M^3; the sample results in the Geryk residence ranged from 0.030 to 0.083 mg/M^3.

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ETHANOL

Ethanol, or ethyl alcohol, is the active ingredient in alcoholic beverages, and is occasionally used as a solvent in various materials. It is also quite volatile, with a vapor pressure of 40 mm HG @ 19° C. Levels in the Geryk residence ranged from 0.024 to 0.037 mg/M^3, well below the current OSHA limit of 1900 mg/M^3.

METHYL CHLOROFORM

Methyl chloroform, more commonly called 1,1,1-trichloroethane, is a chlorinated chemical that is normally used as a degreasing agent. It is very volatile, with a vapor pressure of 100 mm HG @ 20° C. OSHA's current limit is 1900 mg/M^3; levels found in the Geryk residence ranged from 0.014 to 0.024 mg/M^3.

2-METHYLPROPANE

2-Methylpropane, also called isobutane, is commonly used as a propellant for various aerosols. It is found in the gaseous state at normal room temperature and pressure. It does not have an OSHA exposure limit, however butane, similar in structure, has a current limit of 1900 mg/M^3 (however, note that similar structures does not mean that they will have similar toxicological effects). The levels found in the Geryk's residence ranged from 0.19-0.25 mg/M^3.

COMPUTER DATABASE SEARCH

A detailed computer data base search was made to identify the health effects of the above identified materials. This report is attached. In summary, each of these materials have various health effects.

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CONCLUSIONS

Based on the nature of the above specifically identified chemicals, it is suggested that they are not from the window screens. These are relatively common chemicals that may be found in a residence from materials such as paints, cleaning compounds, and pressurized containers. They were all found at very low levels, well below what would generally be considered a health hazard. The levels found were also well below the reported odor thresholds[1], meaning that on the day sampled, the average person would not be able to smell them.

The "unidentified hydrocarbons" may include materials that are from the window screens. However, due to their combined low concentration they were not identifiable by normal GC/MS techniques.

In conclusion, it was not possible during this brief assessment to identify specific chemical compounds believed to be directly related to the coating on the screens. The following reasons may explain why no screen related chemicals were identified during this assessment:

1. The screens had been taken out several months ago, and due to aging and being in a cooler, non-sunny location (garage), may have changed in some way so that this test was not representative of what they off-gassed during prolonged normal installation;

2. On the day of the assessment, the ambient and indoor temperature was cooler than a hot summer day. As stated in the February 21, 1992 report[2] from The University of Alabama at Birmingham, as the temperature of the test samples were increased, additional compounds were released and identified (note that at some point sample pyrolysis was probably taking place).

3. Humidity differences may be important as well. The relative humidity in the 40-45% range is normal for this time of the year; however, during humid periods in the summer can be much higher.

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[1] Odor Thresholds for Chemicals with Established Occupational Health Standards; American Industrial Hygiene Association, Akron, Ohio.

[2] Report from Robert G. Meeks, Ph.D., D.A.B.T., University of Alabama at Birmingham, dated February 21, 1992 to Mr. Anthony Gamble, Phifer Wire Products, Inc.

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Indoor Air Quality Evaluation
at
Three Selected Homes
in
Southeastern Michigan
for
Phifer Wire Products, Inc.
Tuscaloosa, Alabama

Clayton Project No. 45870.00
Draft Report

April 13, 1993

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CONTENTS

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DRAFT

1.0 INTRODUCTION

Mr. Charles E. Morgan, Executive Vice President and Corporate Counsel at Phifer Wire Products, Inc., authorized Clayton Environmental Consultants, Inc. to perform an indoor air quality evaluation in three selected homes in southeastern Michigan. These three households in southeastern Michigan have submitted a variety of complaints, including foul odors, coughing, allergies, burning eyes, and upper respiratory infections that they have associated with the presence of Phifer Wire Products, window screening in their homes. This report provides the results of Clayton's field evaluations.

Mr. Ronald C. Poore, Industrial Hygienist at Clayton, performed three field evaluations on January 18, 1993. The addresses of the three homes evaluated are listed below.

Mr. and Mrs. Golarz	Mr. and Mrs. King	Mr. and Mrs. Fullerton
6710 Sun Valley Drive	5237 Sun Valley Court	6859 Tanglewood Street
Clarkston, Michigan	Clarkston, Michigan	Waterford, Michigan

The purpose of these evaluations was to review the indoor air quality in each of the homes and sample for potential airborne contaminants. The scope of Clayton's services was outlined in Clayton's proposal, which was dated December 3, 1992, addressed to Mr. Morgan, and provided an explanation of the Terms and Conditions under which this work was performed.

Appendix A presents the direct-reading environmental measurements obtained during the field assessments. Appendix B provides the evaluation criteria for indoor air quality used in the home evaluations. Appendix C provides tabulated analytical results of air sampling performed during the home evaluations.

2.0 HOME EVALUATIONS

The findings of Clayton's indoor air quality evaluations are based on visual observations and direct-reading measurements obtained in the occupied spaces of the three homes.

2.1 OCCUPIED SPACE

The three homes are multistoried (including basement), single family residences. The Golarz and King homes are free standing and the Fullerton residence is an attached condominium. The three homes have forced-air, gas-powered furnaces with attached humidifiers and electronic air cleaners.

Renovation and construction materials (e.g., carpeting) emit volatile organic compounds (VOCs), which can be irritating and cause discomfort to sensitive individuals. Research suggests that (1) most offgassing from these materials occurs during the first 6 months after installation, and (2) offgassing can be effectively controlled by providing adequate outdoor air to the occupied space. In each of the three cases, the residents have been living in the homes for at least 3.5 years. Mr. Poore did not detect a new carpet odor or observe unusual sources of VOCs in the three homes.

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DRAFT

2.2 DIRECT-READING MEASUREMENTS

During the evaluations, Clayton performed direct-reading measurements for temperature, relative humidity, carbon dioxide, and respirable particulate (see Appendix A for details). Dry bulb temperatures indoors ranged from 73.8 to 78.5° F. These measurements were above the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)-recommended temperature range of 68.0 to 74°F for the heating season (ASHRAE Standard 55-1992R).

Relative humidity indoors ranged from 19.0 to 26.1% in the homes. These humidities are less than Clayton's guideline recommendations for occupant comfort of 30 to 60%. During the evaluation, the outdoor temperature ranged from 27 to 29°F, and the outdoor relative humidity ranged from 61.0 to 63%.

Airborne particulate concentrations, measured indoors during quiescent conditions, ranged from 10 to 20 micrograms of respirable particulate per cubic meter of air ($\mu g/m^3$). These concentrations are less than Clayton's recommended upper limit of 50 $\mu g/m^3$. The outdoor respirable particulate concentration was 9 $\mu g/m^3$.

Airborne particulate concentrations measured while agitating carpets or fabric-backed furniture (aggressive measurements) ranged from 9 to 33 $\mu g/m^3$ in the homes. In other buildings evaluated by Clayton, aggressive measurements average approximately 100 $\mu g/m^3$. The measurements obtained on January 18, 1993, indicate that housekeeping, especially vacuuming, is adequate to remove settled dusts from porous surfaces in each of the three homes.

Carbon dioxide concentrations indoors ranged from 400 to 450 parts per million (ppm) on the day of the evaluation. These reading are less than the 1,000-ppm upper limit recommended in ASHRAE Standard 62-1989, *Ventilation For Acceptable Indoor Air Quality*. The primary source of carbon dioxide is human respiration, and this "contaminant" concentration serves as an indicator of the adequacy of ventilation.

2.3 HVAC SYSTEM

Each home is served by a gas-fired, forced-air furnace located in the basement. Each unit is fitted with a humidifier and an electronic air-cleaning device that, according to the residents of each home, are cleaned on a regular (at least quarterly) basis. Each furnace also has low-efficiency fiber filters in line in front of the electronic air cleaner. The units appeared to be well maintained. The units are not fitted with outdoor air intakes to supply the indoor living space with outdoor air.

3.0 <u>AIR SAMPLING</u>

Air samples were collected in the three homes for inorganic acids (hydrogen fluoride, hydrogen bromide, hydrogen chloride, nitric acid, and phosphoric acid), amines (ethyl amine, diethylamine, dimethylamine, and methylamine), and VOCs.

3.1 INORGANIC ACIDS AND AMINES

Analytical results for the three samples collected for inorganic acids were less than the limit of detection for each acid based on the method and volume of air collected. Analytical results of the three samples collected for amines were also less than the limit of detection

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for each amine based on the method and air volume collected. Analytical results for the inorganic acids and amines analyses are provided in Appendix C.

3.2 VOLATILE ORGANIC COMPOUNDS

3.2.1 6710 Sun Valley Drive in Clarkston, Michigan

The analytical results of the sample collected for VOCs in the household air at 6710 Sun Valley Drive indicated an airborne benzene concentration of 7.2 $\mu g/m^3$, an ethylbenzene concentration of 3.3 $\mu g/m^3$, a styrene concentration of 6.9 $\mu g/m^3$, a toluene concentration of 7.6 $\mu g/m^3$, and a xylenes (o-, m-, and p- isomers) concentration of 12 $\mu g/m^3$. Other tentatively identified compounds included limonene at a concentration of 9.2 $\mu g/m^3$, benzofuran at 2.7 $\mu g/m^3$, butyl acetate at 6.5 $\mu g/m^3$, hexamethyl cyclotrisiloxane at 0.4 $\mu g/m^3$, and aliphatic and aromatic hydrocarbon concentrations ranging from 0.2 to 25 $\mu g/m^3$. The total hydrocarbon concentration in this home was 86.4 $\mu g/m^3$.

3.2.2 5237 Sun Valley Court in Clarkston, Michigan

The analytical results of the sample collected for VOCs in the household air at 5237 Sun Valley Court indicated an airborne benzene concentration of 0.5 $\mu g/m^3$, an ethylbenzene concentration of 4.2 $\mu g/m^3$, a styrene concentration of 3.8 $\mu g/m^3$, a toluene concentration of 36 $\mu g/m^3$, a 1,1,1-trichloroethane concentration of 300 $\mu g/m^3$, a trichloroethene concentration of 2.0 $\mu g/m^3$, and a xylenes (o-, m-, and p- isomers) concentration of 17 $\mu g/m^3$. Other tentatively identified compounds at this residence include limonene at an airborne concentration of 1.3 $\mu g/m^3$, pyrrolidine at 0.3 $\mu g/m^3$, and aliphatic and aromatic hydrocarbons ranging from 0.3 to 1.5 $\mu g/m^3$. The total hydrocarbon concentration in this home was 370.2 $\mu g/m^3$.

3.2.3 6859 Tanglewood Street in Waterford, Michigan

The analytical results of the sample collected for VOCs in household air at 6859 Tanglewood Street indicated an airborne benzene concentration of 2 $\mu g/m^3$, an ethylbenzene concentration of 2 $\mu g/m^3$, a styrene concentration of 1 $\mu g/m^3$, a toluene concentration of 7.8 $\mu g/m^3$, and a xylenes (o-, m-, and p- isomers) concentration of 7.4 $\mu g/m^3$ Other tentatively identified compounds at this residence include limonene at a concentration of 8.3 $\mu g/m^3$, hexamethyl cyclotrisiloxane at 1 $\mu g/m^3$, octamethyl cyclotetrasiloxane at 0.3 $\mu g/m^3$, and aliphatic and aromatic hydrocarbons at concentrations ranging from 0.9 to 10 $\mu g/m^3$. The total hydrocarbon concentration in this home was 64.2 $\mu g/m^3$.

4.0 METHODS AND MATERIALS

Clayton's American Industrial Hygiene Association-accredited laboratories in Edison, New Jersey, and Novi, Michigan, analyzed the air samples collected during these assessments. The sampling equipment used to collect air samples was calibrated before and after sample collection using a primary standard.

Air samples were collected in each home for amines, inorganic acids, and VOCs. In each case, samples were collected in one room of the house. The doors were closed after the air sampling began and no one entered the rooms until the sampling was completed.

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In the Fullerton house, the screens from the windows were placed in a room in the basement; the air temperature in this room was 82° F. The increased temperature in the room would increase the offgassing of compounds from materials in the room. The room was sealed (to exclude air from the rest of the basement) by first closing the door and then placing towels in the space under the door.

4.1 INORGANIC ACIDS

Samples to be analyzed for inorganic acids were collected using battery-powered air sampling pumps (Mine Safety Appliances Company [MSA] Model C210 Portable Pumps) to draw air at known flowrates through glass tubes containing washed silica gel. The tubes were sealed with polyethylene caps immediately after sampling and packaged in ice for shipment to the laboratory.

In the laboratory, the samples were analyzed using ion chromatography techniques adapted from the procedures outlined in the National Institute for Occupational Safety and Health (NIOSH) Method 7903. Samples were eluted with a bicarbonate/carbonate solution and heated. Aliquots of the solution were then injected into an ion chromatograph, which determined the type and mass of the each anion. Clayton calculated the concentration of each compound using this information and the volume of air collected.

4.2 AMINES

Samples to be analyzed for amines were collected using the same type of air pump and silica gel tubes used for inorganic acids.

In the laboratory, the samples were analyzed using a gas chromatography technique adapted from the procedures outlined in NIOSH P & CAM 221 (modified). Samples were eluted with a solution of methanol, water, and hydrochloric acid. Aliquots of the solution were then injected into a gas chromatograph equipped with a nitrogen-phosphorous detector.

4.3 VOLATILE ORGANIC COMPOUNDS

Samples to be analyzed for VOCs were collected using battery-powered air sampling pumps (MSA Flow-Lite® Portable Pump) that drew air through glass tubes containing Tenax® GC poly (2,6-diphenyl phenylene oxide). The tubes were sealed and packaged in ice for shipment to the laboratory.

In the laboratory, the samples were analyzed using a gas chromatograph equipped with a mass spectrometer (GC/MS) using a technique adapted from the procedures outlined in the United States Environmental Protection Agency (USEPA) Method T01 (modified).

For analysis, the sampling tube was placed in a heated chamber and purged with an inert gas. The inert gas transfers the VOCs from the tube onto a cold trap, then onto the front of the gas chromatography column held at low temperatures (e.g., - 70 ° C). The GC column temperature is then increased and the components eluting from the column are identified and quantified by mass spectrometry. This thermal desorption process, where the entire sample is introduced into the GC/MS, provides enhanced sensitivity.

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5.0 DISCUSSION OF AIR SAMPLING

Results of the home evaluations indicated that there are sources for VOCs in each of the three homes. The following compounds were detected in one or more of the homes:

- Benzene
- Ethylbenzene
- Styrene
- Toluene
- 1,1,1- Trichloroethane
- Xylenes

Each of the compounds detected are common to modern households. Benzene is found in paints and stains, and is used as an intermediate compound in the production of nylon. Ethyl benzene is a common solvent and an intermediate compound in the production of styrene. Styrene is used in furniture construction and is also used in molded household containers. Toluene is found in gums, resins, and coatings used in households. 1,1,1- Trichloroethane is a common solvent used in degreasing solutions, in pesticides, and in textile processing. Xylene is a common solvent found in lacquers, enamels, and rubber cements. During Clayton's evaluations of the three homes, concentrations of the above compounds ranged from less than 0.1 to 300 $\mu g/m^3$.

During interviews, the homeowners expressed interest in medical monitoring to determine exposure, if any, to the compounds found in the evaluation. Compounds and their biological exposure index (BEI) are provided below for the homeowners' information only.

Compound	Biological Exposure Index
Benzene	Phenol in urine Benzene in blood
Ethylbenzene	Mandelic acid in urine Ethylbenzene in blood
Styrene	Mandelic acid in urine Phenylglyoxylic acid in urine Styrene in blood
Toluene	Hippuric acid in urine Toluene in blood
1,1,1- Trichloroethane (Methyl chloroform)	Sum of trichloroethanol & trichloroacetic acid in urine 1,1,1- Tricholorethane in blood
Xylenes	Methyl hippuric acid in urine Xylene in blood

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The following compounds were tentatively identified in one or more of the homes:

- Butyl acetate
- Benzofuran
- Hexamethyl cyclotrisiloxane
- Limonene
- Octamethyl cyclotetrasiloxane
- Aliphatic hydrocarbons
- Aromatic hydrocarbons

Butyl acetate is a common solvent for lacquers, enamels, and thinners. Benzofuran is used in adhesives, floor tile binders, and printing inks. Limonene is a derivative of lemon, orange, or other oils and is used in perfumes, flavorings, and cleaning solvents. Hexamethyl cyclotrisiloxane and octamethyl cyclotetrasiloxane are silicone oils that are found in a variety of products such as adhesives, lubricants, cosmetics, and polishes. Various aliphatic and aromatic hydrocarbons are contained in most, if not all, products used in households.

The concentrations of the above listed compounds ranged from 0.2 to 10 $\mu g/m^3$.

Symptoms of VOC exposure (depending on the dose) can include fatigue, headache, drowsiness, dizziness, weakness, joint pain, peripheral numbness or tingling, blurred vision, skin irritation, irritation of the eyes and respiratory tract, and difficulty concentrating.

A dose-effect relationship has not been established, but effects at levels less than permissible exposure limits for workers in industry have been described. Individuals who appear to demonstrate multiple chemical sensitivity report severe reactions to a variety of VOCs and other compounds released by building materials and consumer products.

These reactions can occur after a single exposure or a sequence of doses, after which time a far lower dose can provoke symptoms.

Concentrations of some specific VOCs in indoor non-industrial air have been reported by Siefert & Abraham 1982 ("Indoor air concentrations of benzene and some other aromatic hydrocarbons." Ecotox. Environ. Safety. 6: 190-192)

Contaminant	Concentration ($\mu g/m^3$)
Benzene	15 to 18
Toluene	60 to 62
M & P-xylene	21 to 29
Ethylbenzene	11 to 15

Concentrations of total hydrocarbons in non-industrial indoor air have been reported by Sheldon 1988 (Indoor Air Quality in Public Buildings. Vol II U.S. Environmental Protection Agency).

Contaminant	Concentration ($\mu g/m^3$)
Aromatic hydrocarbons	21 to 1,100
Aliphatic hydrocarbons	11 to 270

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